

NON-PROVISIONAL APPLICATION FOR UNITED STATES PATENT

FOR

An Optoelectronic Module with Integrated Cooler

Inventor
Tieyu Zheng

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Prepared by: Al AuYeung
Schwabe, Williamson & Wyatt, P.C.
Pacwest Center
1211 SW Fifth Ave., Stes. 1600-1900
Portland, Oregon 97204

aauyeung@schwabe.com
503-796-2437

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FIELD OF THE INVENTION

[0001] The present invention relates generally to the field of optoelectronics.

BACKGROUND OF THE INVENTION

[0002] Laser light has been employed to facilitate communication.

[0003] Typically, for intermediate or long range communication, the laser light source has to be cooled to ensure proper functioning of the optoelectronics, that is, the optical and electronic components within the optoelectronic modules. Currently, what is known as the “butterfly can” is probably the most popular form factor employed for this kind of laser transmitter modules, i.e. those requiring the laser light sources and/or their companion electronics to be cooled. In general, “butterfly can” has a relatively large footprint, and is relatively expensive to make.

[0004] Recently, a number of smaller footprint transceivers, such as XFP or SFP, have emerged. Traditional packaging, such as butterfly can, is unable to meet the smaller footprint and lower cost requirement. [XFP = 10-Gigabit Small Form Factor Pluggable, and SFP = Small Form Factor Pluggable]

[0005] Transistor-On-line (TO) packaging has been developed for 2.5 Gbit/sec or lower speed communication. It fits the smaller transceiver’s footprint, and has lower cost. Applying TO packaging to higher speed applications, such as 10Gbit/sec, would meet the new market needs. However, traditional TO cans have no provision for cooling elements, which are often required for high speed applications of 10Gbit/sec and beyond for intermediate or long range communication.

[0006] In other words, butterfly cans are designed to accommodate cooling elements, but their footprints are too big, and too costly to manufacture, whereas TO packaging has a smaller footprint, and lower cost to manufacture, but it has no provision for cooling elements for high speed and long range applications requiring such cooling.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The present invention will be described by way of exemplary embodiments, but not limitations, illustrated in the accompanying drawings in which like references denote similar elements, and in which:

[0008] **Figure 1** illustrates an exploded view of an optoelectronic module, in accordance with one embodiment of the present invention;

[0009] **Figure 2** illustrates a side view of the optoelectronic module of **Fig. 1**;

[0010] **Figure 3a-3b** illustrate a perspective view and a bottom view of the thermo electric cooler of **Fig 1-2**, in accordance with one embodiment; and

[0011] **Figure 4** illustrates an example system having the optoelectronic module of **Fig. 1-2**, in accordance with one embodiment.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0012] Illustrative embodiments of the present invention include, but are not limited to, an optoelectronic module, a communication interface and/or system having such optoelectronic module.

[0013] Various aspects of the illustrative embodiments will be described using terms commonly employed by those skilled in the art to convey the substance of their work to others skilled in the art. However, it will be apparent to those skilled in the art that the present invention may be practiced with only some of the described aspects. For purposes of explanation, specific numbers, materials, and configurations are set forth in order to provide a thorough understanding of the illustrative embodiments. However, it will be apparent to one skilled in the art that the present invention may be practiced without the specific details. In other instances, well-known features are omitted or simplified in order not to obscure the illustrative embodiments.

[0014] The phrase “in one embodiment” is used repeatedly. The phrase generally does not refer to the same embodiment; however, it may. The terms “comprising”, “having” and “including” are synonymous, unless the context dictates otherwise.

[0015] Referring now to **Figures 1-2**, wherein an exploded view and a side view of an optoelectronic module, in accordance with one embodiment, is shown. As illustrated, for the embodiment, optoelectronic module **100** includes a laser light source **102** to provide laser light for encoding data thereon for communication purpose, and a thermo electric cooler (TEC) **110** thermally coupled to laser light source **102** to cool at least the laser light source **102** during operation. More specifically, for the embodiment, laser light source **102** is disposed at the “top” surface of TEC **110**. In alternate embodiments, laser light source **102** may be mounted on a submount that is on the top of TEC **110** instead.

[0016] Note that the reference to the surface of TEC **110** on which laser light source **102** is disposed as a “top” surface is made merely for ease of description and understanding. The surface could have been referred to e.g. as a “bottom” or a “side” surface. Whether, it should be referenced as a “top”, a “bottom” or a “side” surface is a matter of

perspective, depending on how optoelectronic module **100** is viewed. Accordingly, the reference convention is not to be read as restrictive of the invention. Further, this note applies to all subsequent references to other surfaces of other elements as “top”, “bottom” or “side” surfaces. That is, all such references are for ease of description and understanding. The surfaces could have been referenced in other manners depending on how the elements are viewed respectively, and the references are not to be read as restrictive on the invention.

[0017] In various embodiments, laser light source **102** may be a vertical cavity surface-emitting laser device, a Fabry-Perot laser device, a distributed feedback laser device, a laser diode device, and other laser devices of the like. Further, laser light source **102** is driven for a high speed communication application, e.g. 10Gbit/sec or higher, requiring cooling during operation.

[0018] In various embodiments, TEC **110** is thermally rated to meet at least the thermal dissipation requirement of laser light source **102**. Referring now briefly to **Fig. 3a-3b** where a perspective view and a bottom view of TEC **110** in accordance with one embodiment is illustrated, respectively. As shown, for the embodiment, TEC **110** is further advantageously provided with a T-shape bottom **302**, allowing cavities **304a-304b** to be “defined”. For these embodiments, cavities **304a-304b** are employed to facilitate routing of electrical traces to TEC **110**, which contribute to the compactness or relative small footprint of optoelectronic module **100**.

[0019] Referring back to **Figs. 1-2**, optoelectronic module **100** is further advantageously formed with a stepped substrate **112**, having a number of vias **122a-122b**. Input and/or output pins **116** are attached to the “bottom” surface of substrate **112**. Vias **122a** are employed to facilitate routing of electrical connections from selected one(s) of I/O pins **116** to TEC **110**. Usage of vias **122b** will be further described below. In various embodiments, the lower portion of stepped substrate **112** is about 1mm in “height”, and the higher portion is about 1.5mm in “height”. In alternate embodiments, substrate **112** and the different portions may have heights of other values. Similar to the earlier note with respect to referencing a surface as a “top”, “bottom” or “side” surface, the enumerated dimensions could have been described as “length” or “width”, depending on

how optoelectronic module **100** is viewed. Accordingly, these dimension references are also not to be read as restrictive on the invention.

[0020] As illustrated, for the embodiment, TEC **110** is disposed in the lower portion of substrate **112**, and the “step” or higher portion of substrate **112** has a height that is substantially the same as TEC **110**, to allow laser light source **102** to be substantially coplanar with the “top” surface of the step or higher portion of substrate **112**. As illustrated, this feature allows e.g. a driver or an amplifier **104** to be optionally placed in very close proximity of laser light source **102**. For these embodiments, vias **122b** are employed to facilitate routing of electrical connections from selected one(s) of I/O pins **116** to optional driver/amplifier **104**. The co-planar and proximal attributes enable relatively short leads to be employed to electrically couple laser light source **102** to optional driver or amplifier **104** (if it is disposed as shown). The arrangement potentially contributes to improving the performance of optoelectronic modules **100**.

[0021] In various embodiments, substrate **112** is made of a ceramic material with a suitable thermal conductivity. Similarly, ceramic may be used to form the substrate of RF circuitry. More specifically, in various embodiments, the ceramic material is a selected one of aluminum nitride, beryllium oxide, alumina, and other ceramic materials with suitable thermal conductivity and similar dielectric constants.

[0022] Still referring to **Figs 1-2**, for the embodiment, optoelectronic module **100** further includes mirror assembly **108** which is employed to assist in re-directing the light bundles emitted by laser light source **102** from a direction that is substantially parallel with the “top” surface of TEC **110** to a direction that is substantially orthogonal to the “top” surface of TEC **110**. Any one of a number of mirrors (conventional, micro or otherwise) may be employed to implement mirror assembly **108**. In alternate embodiments, prisms, and/or other optical devices with like properties may also be employed in conjunction or instead.

[0023] Further, in various embodiments, one or more other electronic elements, represented by element **106**, may also be disposed on the “top” surface of TEC **110**.

[0024] Continuing to **Figs 1-2**, optoelectronic module **100** further includes overhanged ring **114**, which is disposed on the perimeter of substrate **112** as shown. Overhanged ring **114** is provided to assist in the engagement of cap **118** to seal laser light source **102** and

the various electronic elements, such as elements **104-106**, including optical elements, such as mirror assembly **108**.

[0025] More specifically, overhanged ring **114** is designed to mate with flanges **119** of cap **118**. Cap **118** may be mated with overhanged ring **114** in a variety of manners, including but are not limited to welding, in particular, projection welding. In various embodiments, overhanged ring **114** is about 0.5 mm in thickness.

[0026] For the embodiment, overhanged ring **114** is substantially square in shape, however, in alternate embodiments, overhanged ring **114** may assume other geometric shapes, including but are not limited to other polygon, circular or oval shapes.

[0027] For the embodiment, in addition to flanges **119**, cap **118** includes optical window **120**. More specifically, optical window **120** is complementarily disposed at the center portion of cap **118** to facilitate exit of the orthogonally re-directed laser light bundles emitted by laser light source **102**. In various embodiments, optical window may be a flat glass window, a ball lens, an aspherical lens, a GRIN lens, or other lens of the like.

[0028] **Figure 4** illustrates an example communication system, in accordance with one embodiment. As illustrated, example system **400** includes data routing subsystem **402** and networking interface **404** coupled to each other as shown. Networking interface **404** is employed to optically couple communication system **400** to a network, which may be a local area network, a wide area network, a telephone network, and so forth. These networks may be private and/or public. For the embodiment, networking interface **404** includes in particular, optoelectronic module **100** of **Fig. 1**, to facilitate optical communication. For the purpose this specification and the claims, networking interface **404** may also be referred to as a communication interface.

[0029] Still referring to **Fig. 4**, for the embodiment, data routing subsystem **402** includes processor **412** and memory **414** coupled to each other as shown. Memory **414** has stored therein a number of data routing rules, according to which processor **412** routes data received through networking interface **404**. The data routing rules may be stored employing any one of a number data structure techniques, including but are not limited to tables, link lists, and so forth. Data may be received and routed in accordance with any

one of a number of communication protocols, including but are not limited to the Transmission Control Protocol/Internet Protocol (TCP/IP).

[0030] Except for the incorporation of optoelectronic module **100** with networking interface **402**, elements **402-404** represent a broad range of these elements known in the art or to be designed

[0031] In various embodiments, example system **400** may be a router, a switch, a gateway, a server, and so forth.

[0032] As those skilled in the art would appreciate, the foregoing embodiments provide an optoelectronic package having a relatively small footprint, and yet able to accommodate cooling elements for a high speed e.g. 10Gbit/sec application. In various embodiments, the length and width of the module may be about 5.4mm, and the height of the module may be about 5~10mm, providing a substantially smaller foot print than the butterfly can, whose length is over 19mm, width over 7mm, and height over 7mm. A laser in such package may nonetheless dissipate e.g. 0.1W heat, with a heat of e.g. 0.2~0.4W going into the module from the ambient, yet the TEC of this footprint can dissipate the total heat (as much as 0.5W) to maintain the temperature of the laser device at about 25~35°C, while the module case in the communication system is about 70°C.

[0033] Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a wide variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described, without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the embodiments discussed herein. Therefore, it is manifestly intended that this invention be limited only by the claims and the equivalents thereof.